

# NASA Perspective on Radiation Hardness Assurance (RHA) for Hybrid Devices<sup>†</sup>

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<sup>†</sup> Work partially supported through the NASA Electronic Parts and Packaging Program

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# ***Outline***

- **Introduction/Problem Statement**
- **RHA Issues**
- **Hybrid RHA at NASA**
- **Test Issues**
- **Data Analysis Issues**
- **COTS**
- **Summary**

# ***Problem Statement***

- To understand the radiation hardness level of a hybrid device that typically consists of many technologies, detailed testing and analysis is required.
- The current budgetary conditions of most NASA flight projects is in direct conflict with these requirements.

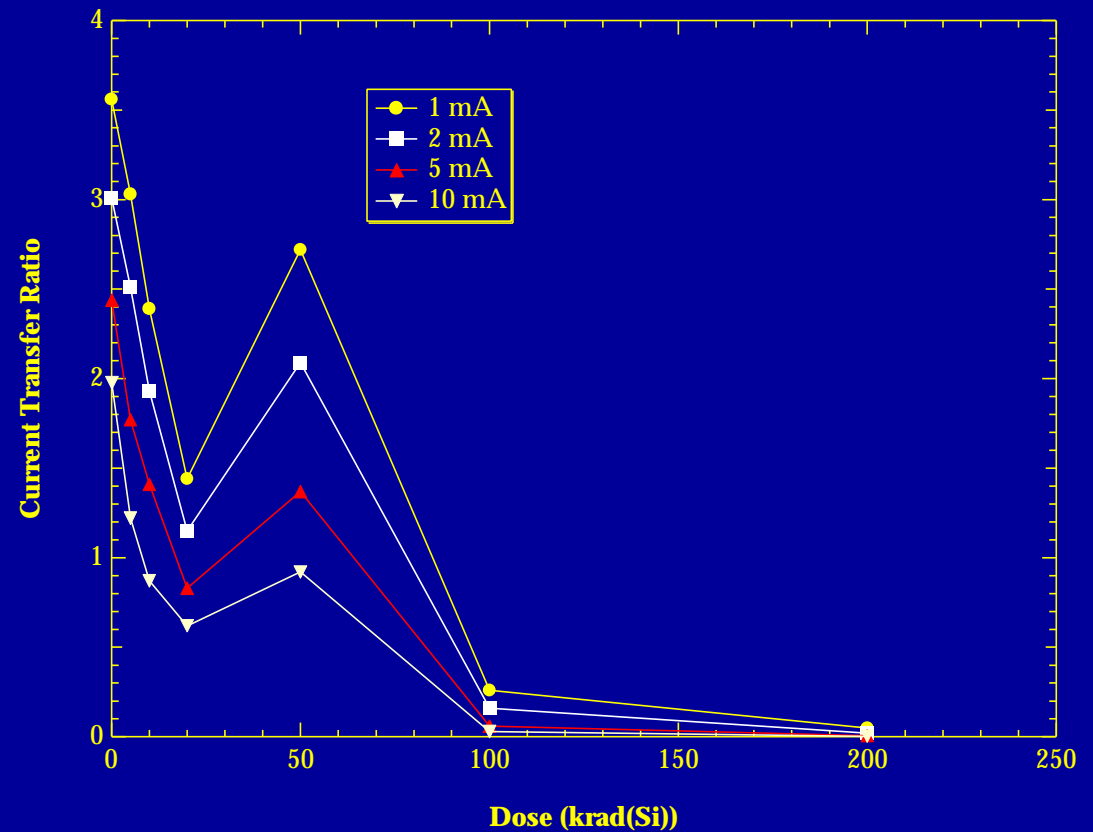
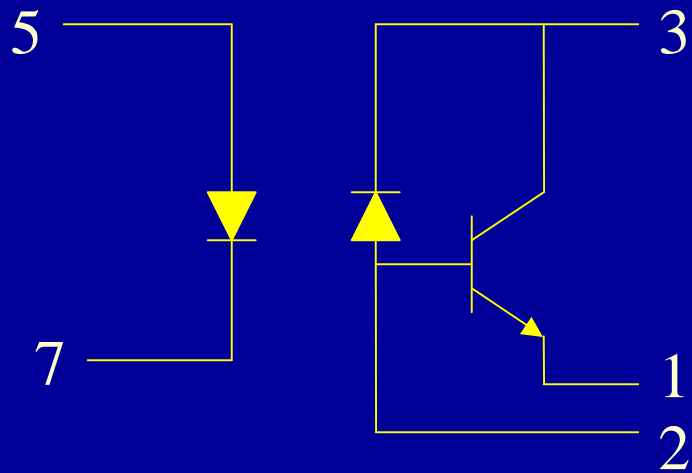
## *Sample RHA Issues*

- Cost and Procurement Lead Time
- Traceability
- Everything can possibly go wrong
  - CMOS low dose rate, ELDRS, Displacement Damage, SEL, SEB, SEGR, SEU, SET, SEFI, etc.
- Worst Case vs. Application Specific

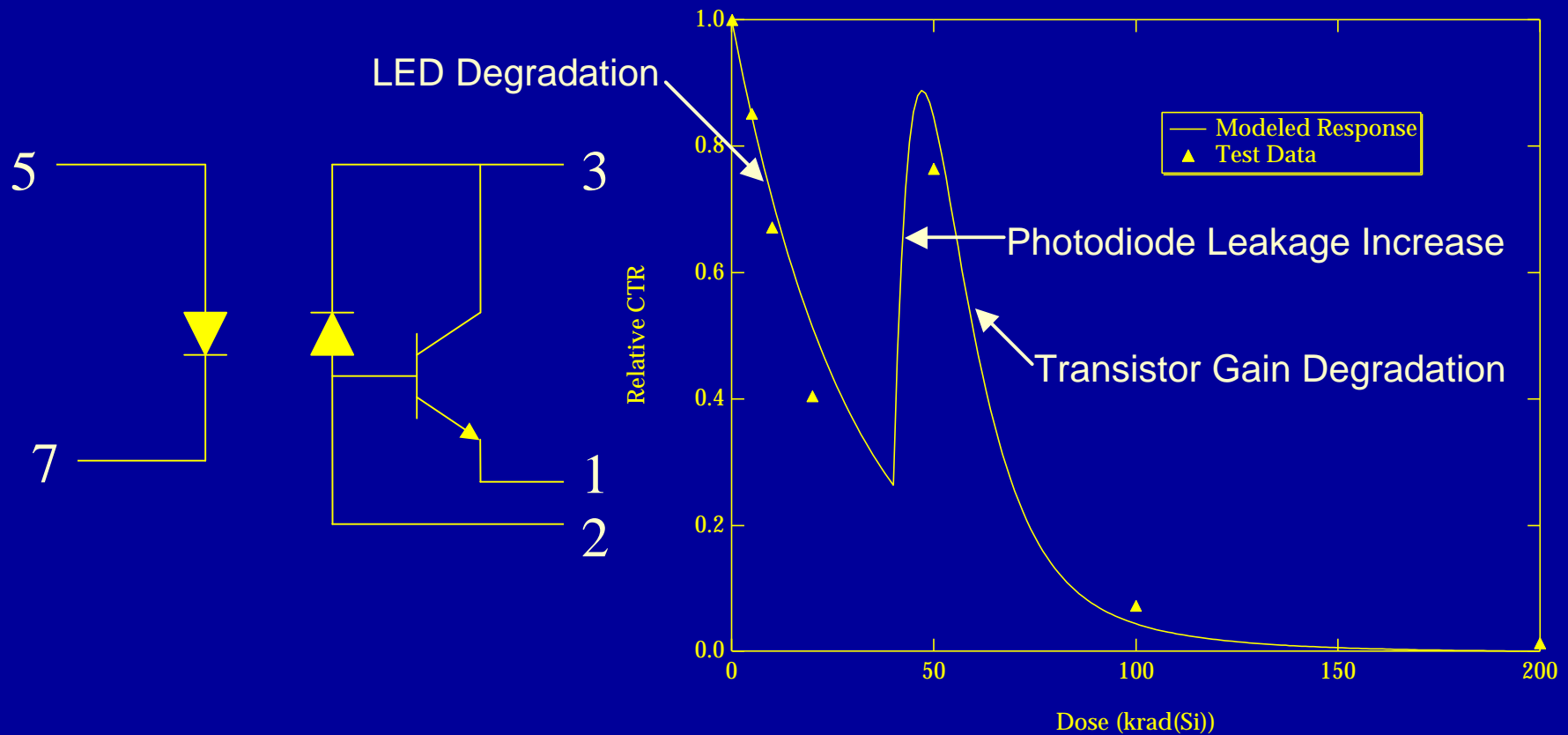
# *Hybrid RHA at NASA*

- Working with the Vendor
  - Information
  - Cooperative investigations
  - Design modifications
- Testing
- Analysis
  - Piece-part Analysis
  - Test Data Analysis
  - System Level Impact Analysis

# Cooperative Investigation with Micropac



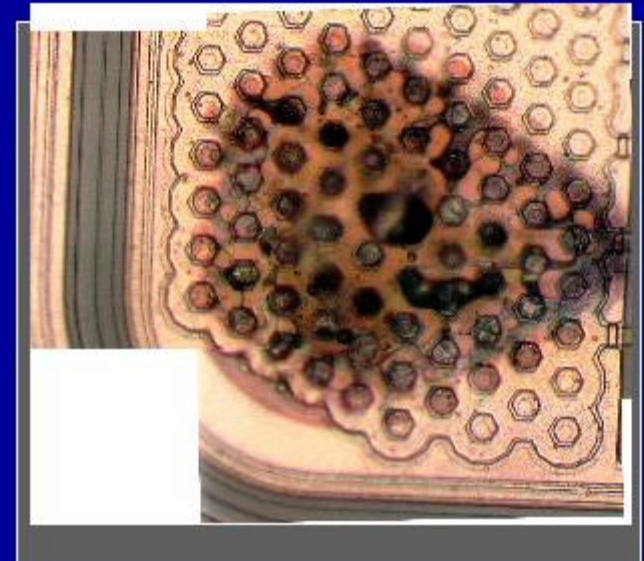
# Cooperative Investigation with Micropac





# *Space Station (ISS) DC/DC Converters*

- High Voltage DC/DC converters from Modular Devices, Inc. (MDI) were tested to examine the possibility of their use on ISS. A mixture of devices with 120 volt inputs and single or dual 5, 12, or 15 volt outputs were used.
- Initial testing showed a low LET threshold for destructive burnout of the power MOSFET (see photo below).
- MDI cooperated in this effort by replacing the “very good” power MOSFET used in the original design with a RADHARD equivalent.
- Follow-on tests of these new devices showed a higher LET threshold for failure but not considered RADHARD.
- Could indicate a circuit-induced failure mode that is not solved by RADHARD part selection.



# Space Station DC/DC Converter Results Summary

Parts with  
RadHard  
MOSFET

Part Number	Volts	Load	LET	Pass/Fail
MDI3051RES05ZF	126	10%	12	Pass
	113	50%	12	Fail
MDI3051RES12ZF	120	25 -100%	12	Pass
	126	25 -100%	12	Pass
	120	25 -75%	28	Pass
	120	100%	28	Fail
MDI3051RES15ZF	120	25 -100%	28	Pass
	120	75%	28	Fail
MDI3051RES05ZF_A	126	50%	28	Pass
	126	50%	37	Pass
	126	75%	37	Fail
MDI3051RED12ZF_A	120, 126	75%	28	Pass
	120	75%	37	Pass
	120	25%	60	Pass
	120	75%	60	Fail
MDI3051RED15ZF_A	120, 126	75%	37	Pass
	120	25%	60	Pass
	120	75%	60	Fail

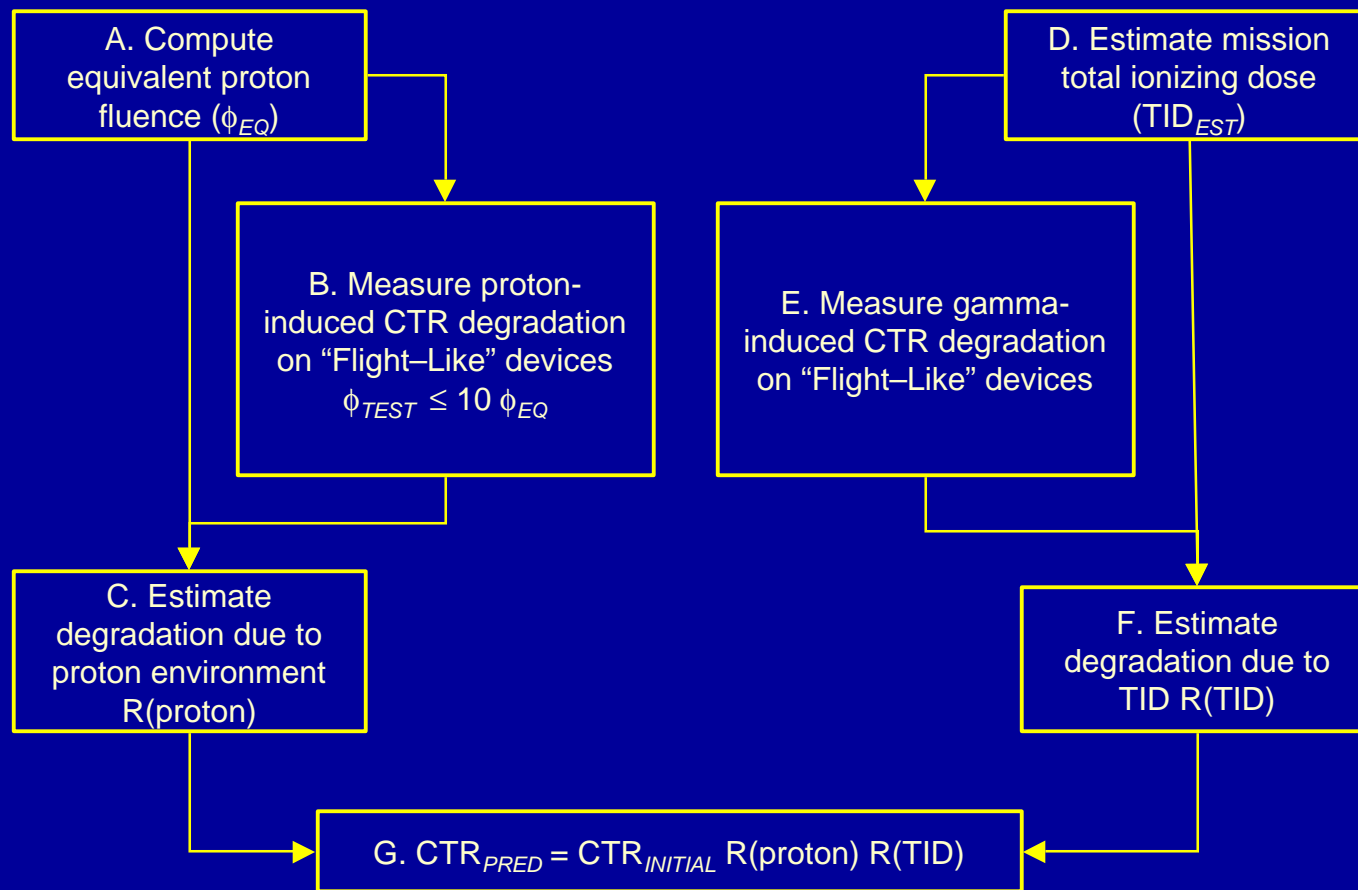
# Testing Issues

- Cost and Procurement Lead Time
  - Extremely Small Sample Size
  - Can lead to “late in the game” testing
- Everything can possibly go wrong
  - With the small sample size, testing has to be prioritized/combined
- Worst Case vs. Application Specific
  - With small sample size, testing is generally done application specific
  - Multiple applications within a project may force more generic testing
    - Can worst case conditions really be determined
    - Test parameter space can be extremely large for generic testing
- High Voltages and Currents
  - Care in testing due to destructive events and constrained sample size
  - Cooling of test structures often required which can be problematic when working in a vacuum
- Multiple devices exposed simultaneously
  - Don’t know which device may be the problem
  - May have some multiple event interactions
- Packaging can restrict device access

# *Data Analysis Issues*

- Piece-part Analysis
  - If complete parts list and radiation data available, can treat as any other system analysis
  - Main issues are:
    - Rarely are both items available
    - The “system” designer is usually not available
- Test Data Analysis
  - Must go from test data to in-flight predictions
    - Multiple data sets
    - Multiple space environments
- System Level Impact Analysis
  - In-flight predictions for hybrid are then analyzed for system-level impact, mitigation options and risk assessment
  - Trades between mitigation, risk assessment and risk acceptance are at the system and project manager levels

# Optocoupler Flight Predictions



*Taken from Reed, et al., "Guideline for Optocoupler Ground Radiation Testing and Optocoupler Usage in the Space Radiation Environment"*

# *Commercial-Off-The-Shelf (COTS) Issues*

- COTS Hybrids
  - Traceability is the real issue
  - Part-to-part variability can be significant
    - COTS parts are used
    - Various vendor parts may be used in same location
    - In general, no such thing as lot control
- COTS Printed Circuit Boards as “Hybrids”
  - COTS PCB can be treated as a hybrid on a larger scale
  - All the same issues apply as noted above
  - Often the PCB is integral to larger system and the observed effects can only be seen at that level
  - Heavy ion testing is often impossible

# *Summary*

- There are numerous issues when dealing with hybrid devices
- NASA takes a system-level-down approach to RHA
- It cannot be overstated how critical radiation testing, how the devices are tested, to good RHA
- NASA also works to make the vendor an integral part of the RHA process, as much as the vendor is willing to participate
- Test data analysis to flight risk assessments can be a very complex business, especially when dealing with many applications within a flight project
- COTS is COTS